

Freshwater mollusc of northeast India and need for developing a sustainable farming practises for potential inclusion as a component of blue revolution

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ABSTRACT

The phylum Mollusca are widely diverse group which are spread across freshwater and marine environment. However, the freshwater mollusc are lesser known. Freshwater mollusc such as snails and bivalves are not only a delicacy in the north-eastern states of India but also has been used in traditional medicine. Till date, huge data are available for the food value and health benefit of marine gastropod and bivalves which has economic importance and has export potential. But the north eastern region of India is not a ware of those marine species which has scientific information. Therefore, need has been arisen to understand the locally available underutilized and underrepresented freshwater mollusc species of Manipur. This study aims to assess the current use of edible freshwater molluscan resources (such as gastropods and bivalves) and the potential for value-adding the molluscan fisheries in Manipur, India. A total number of 1500 mollusc consumer and 31 state government personals were interviewed. The consumer consists of 56.66% female and 43.33% male population. Majority (47.13%) of the respondents belong the annual income group of <Rs. 1 Lakh/ annum (USD 1,200 approx.) and majority (40%) of the respondents have completed their higher secondary education. The three edible varieties of snails that is *Brotiacostula* (Laitharoi), *Cipangopaludina* (Labuktharoi) and *Filopaludina bengalensis* (Tharoiningkhabi) are consumed by all the respondents. However, only 97% of the respondents eat freshwater mussel, *Lamellidens marginalis* locally known as kongreng. The freshwater mollusc has also been reported to use in traditional medicine for chicken pox recovery and strengthening of stomach. Consumers have suggested for value addition potential such as canning and pickling. Most of the respondents from Government Departments indicated there was limited scope for funding new species aquaculture development in Manipur and India at the larger picture. This study also established the fact the freshwater snails and mussels are a delicacy for this region of northeast India. It is very much necessary to establish a sustainable supply through research and development to enhance the livelihood of the shellfish harvester of Manipur, India. Otherwise, continuous harvest from the wild could be a question to the sustainability in the long-term fisheries.

Key words: Mollusc, Sustainable, Value add, Traditional medicine, Invertebrates.

Introduction

Molluscs include approximately 7% of all living ani-

mals, occupying the second largest animal phylum on Earth, just next to arthropods. There is an estimated 200,000 mollusc species (Bouchet, 2006), of

these about 5000 species are reported from fresh water (Abbott, 1989; Seddon, 2000). Fresh water molluscs including snails and bivalves are considered as an important food source for humans (Khalua *et al.*, 2014). Bioactive medicinal compounds from molluscs has potential application in both therapeutics and pharmaceutical development (Sarumathi *et al.*, 2012). Besides the therapeutic and pharmaceutical products, there are also important nutraceuticals or natural health products reported from molluscs (Gibson and Gibson, 1998; Sukumaran *et al.*, 2010; Abdulazim *et al.*, 2012). Molluscs are important and considered to have high protein, essential amino acids and low fat content (Desai, 2000; Nettleton, 1995).

Bivalves and gastropods mainly the snails have been consumed as food as well as medicine by various ethnic group in several Indian states (Imsong and Murali, 2023; Jadhav *et al.*, 2020; Jadhav *et al.*, 2023). Among the freshwater bivalves, *Lamellidens* spp. are commonly eaten along the northeastern states of India (Mukherjee and Basu, 2008). Some of the common edible freshwater snails available in northeast India includes *Pila globosa*, *P. olea* (Ampullariidae), *Filopaludina bengalensis*, *Angulyagra oxytropis*, *Cipangopaludina lecythis* (Viviparidae), *Paludomus blanfordiana*, *P. crassa*, *P. pustulosa* (Paludomidae), *Brotia costula* (Pachychilidae) (Borkakati *et al.*, 2009; Jadhav *et al.*, 2020; Tripathy and Mukhopadhyay, 2015).

Among the northeastern states of India, Manipur is one of the hilly landlocked region located. Its fisheries solely consist of inland water fisheries. Manipur is registered third highest fish producer after Assam and Tripura among the northeastern states of India (GoM, 2015). In spite of the fact that fishery production of the state is very low, the demand for fish among the people of Manipur is very high. The contribution of mollusc fisheries in the total fisheries of Manipur is still invisible. Fisheries plays a very important role in the socioeconomic development of the state and in providing livelihood for huge section of economically backward population of Manipur.

Freshwater edible mollusc such as bivalves and gastropod of Manipur are among the delicacies consumed by most of the people of the state. However, majority of the people of the state consumed just because of the taste with no understanding of the nutritional or biochemical information. In India, few scientific study on freshwater gastropod and

bivalves resources are conducted along Tamil Nadu in south (Ulagesanand Kim, 2018; Packia Lekshmi *et al.*, 2014; Gayathri *et al.*, 2017) and West Bengal in the east (Chakraborty *et al.*, 2015).

Till date, huge data are available for the marine gastropod and bivalves which are of economic importance and has export potential (Benkendorff *et al.*, 2015; Ngangbam *et al.*, 2015; Ngangbam *et al.*, 2019 and Nongmaithem *et al.*, 2018). The north eastern region of India are not a ware of those marine gastropods and bivalves resources which has scientific background that are harvest in the coastal states of India. Therefore, it is very important to understand the locally available underutilized and under represented freshwater mollusc species of Manipur for the contribution on overall health and wellbeing of the region. Traditional uses of gastropod and bivalves for medicinal purpose has been practice since ancient time from biblical era (Nongmaithem *et al.*, 2018). Various studies have been conducted mostly from marine origin gastropod and bivalves to substantiate the traditional uses of gastropod by screening the presence of bioactive compounds present and its ecological role (Benkendorff *et al.*, 2015). Freshwater gastropods of northeast India also has its history of uses in traditional medicine and as food but no studies have been conducted so far on assessing the knowledge of the people and their perception of mollusc as food as well as traditional medicinal usage. This clearly demonstrate the need to undertake scientific study of the consumer's perception on freshwater mollusc which is also related to the food being taken as delicacy for the people of Manipur. With this background, the main aim of the study is to assess the current use of edible molluscan resources (such as gastropods and bivalves) and the potential for value-adding the molluscan fisheries in Manipur for the scope of income generation and livelihood enhancement.

Materials and Methods

Recruitment of participants

There are 16 districts in Manipur which consist of the valley and hilly regions. The study was conducted on eight districts, which consist of the valley districts and some selected hilly districts that has potential freshwater bodies for mollusc harvest and consumption. The selected districts were namely Bishnupur, Senapati, Imphal East, Imphal West,

Thoubal, Chandel, Kangpokpi and Jiribam district. A total number of 1500 mollusc consumer (180 Bishnupur district, 103 Senapati district, 300 Imphal East, 280 Imphal West, 287 Thoubal, 100 Chandel, 100 Kangpokpi and 150 Jiribam) were surveyed for the assessment of the current use of edible mollusc resources and the potential for value-adding the molluscan fisheries in Manipur. Consumers were randomly interviewed at each of these eight locations. Separate survey was conducted for the state fisheries department personnel. A total number of 31 personal (3 Bishnupur district, 3 Senapati district, 5 Imphal East, 5 Imphal West, 5 Thoubal, 3 Chandel, 3 Kangpokpi and 4 Jiribam) from state fisheries department of eight selected districts were surveyed which consist of Fisheries officer, Assistant Fisheries officer and Fisheries Inspector.

All these surveys were conducted using verbal interviews in the local language (Manipuri). Each participant was provided with an "Invitation to Participate in Research" form. Only those participants who agreed to participate were selected.

Survey design

Separate surveys were conducted for different group of people: mollusc consumers of eight districts of Manipur and personnel of state fisheries department of eight districts of Manipur. Questions for mollusc consumer survey include assessment of their preferred way to consumed molluscan resources such as gastropods and bivalves for value addition. Questions for the state fisheries department personnel accessed mollusc harvest, its contribution in total fisheries of the state, aquaculture interest and promotions among the fish farmers. Both the groups provided demographic and socioeconomic information.

Survey data analysis

The qualitative and quantitative data analysis were carried out. Descriptive statistics of the data provided insights into the market chain and its participants. Qualitative information elicited from the respondents was collated and analysed using *NVivo10* and *Word Cloud* software. The comments and suggestions of participant during the survey were classified and coded, and thematic frequencies were identified for interpretation and analysis.

Results

Responses from the freshwater mollusc consumer survey in Manipur

Socio-demographic profile of the mollusc consumer

A total number of 1500 respondents have participated in the interview. The genders of the consumer were randomly selected and 56.66% of the respondents were female and 43.33% male population (Figure 1). Majority (47.13%) of the respondents belongs the annual income group of <Rs. 1 Lakh per annum (USD 1200) followed by 30% who belongs to the income group between Rs. 1 to 5 lakhs (USD 1200-6000) (Figure 2). Majority of the respondents of 40% have completed their higher secondary educations followed by 32.6 % with high schools and 15% were collegiate (Figure 3).

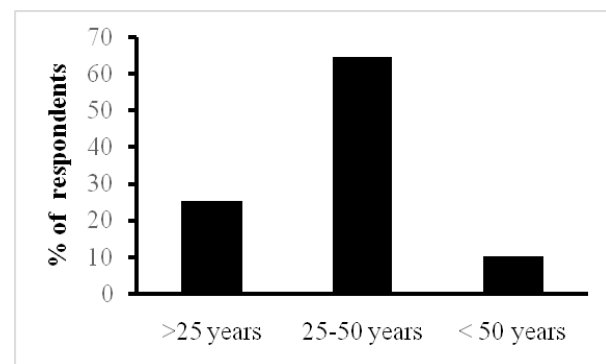


Fig. 1. Age distribution of the mollusc consumer.

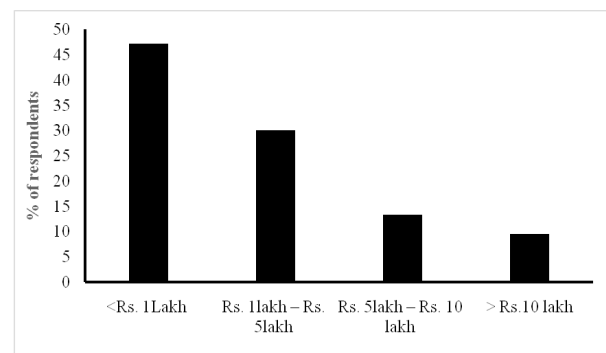


Fig. 2. Average yearly income in Indian rupees.

Out of the 1500 mollusc consumer, 100% of the respondent consumed all the three edible varieties of snail that is *Brotia costula* (Lai tharoi), *Cipangopaludina lecythis* (Labuktharoi) and *Filopaludina bengalensis* (Tharoininghabi) (Figure 4).

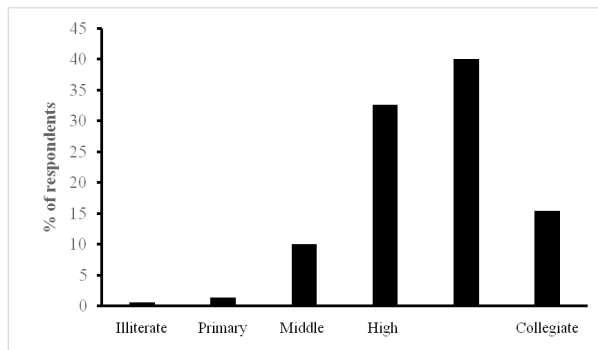


Fig. 3. Educational levels of the consumer.

However, only 97% of the respondents eat freshwater mussel, *Lamellidens marginalis* locally known as kongreng. Some of the respondents who did not participate in this interview, as they did not consume snail have identified the reason for not consumption due to religious belief, bad odor and allergy. Apart from food, consumers have also suggested the usage of mollusc waste such as shells and viscera for feeding poultry.

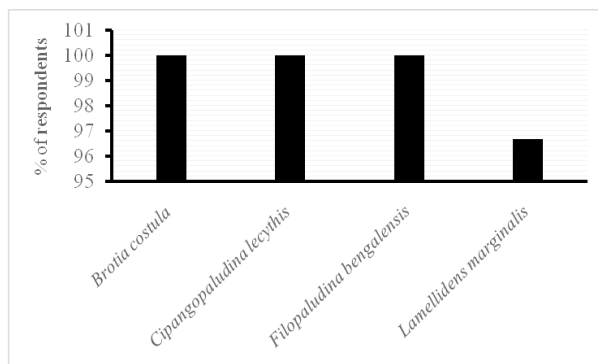


Fig. 4. Locally consumed freshwater snail and bivalve species.

Frequency and preferred way to consume freshwater mollusc

Majority of the 46.67 % consumed the mollusc meat more than three times a month, 43.33% consumed the mollusc meat weekly and only 10% consumed twice a month. Majority (54.13%) of the consumers prefer to eat the snail meat by boiled and cooked with spices and vegetables whereas 26.67 % of the consumer prefer to eat the boiled and fried with spices and vegetables. Fewer sections from hill districts which consist of 19.2 % preferred to eat the mollusc meat cooked with pumpkin and also used as taste enhancer for cooking the meat such as chicken, pork and beef.

Traditional uses of freshwater mollusc

Majority (66.8 %) of the consumers have the knowledge of using mollusc in traditional medical purpose. The juice that comes out of the whole snail of *Filopaludina bengalensis* (tharoiningkhabi) is used in traditional medicine. The pointed aperture of the shells was chopped and the juices that comes out of the snail were collected and has been used for the chicken pox recovery till date. The ashes of the burnt whole body of the snails were also reported to apply for wound healing. It is also a tradition to eat *Brotiacostula* (Lai taroi) a day before Manipuri new year which falls in the month of April and is believed to strengthen the stomach. Further, the health benefits of eating the snail as identified by the consumer includes good for stomach and eyes, rich source of calcium, protein, fiber, vitamins and minerals.

Value addition for freshwater mollusc

For value adding the meat of mollusc, majority (Figure 5) of the consumers express their preference for developing a pickle and canned products as it can be used as taste enhancer or appetiser and for long-term storage. Further, for instant consumption fried using coats of all purpose flour or chickpea flour along with spices and crumbs were also suggested. Some of the respondents have also suggested the possibility to include in the frozen outlet by boiling the meat and coat with flour mix with spices and breadcrumb.

Response from the state fisheries department personal

A survey on the state fisheries department have re-

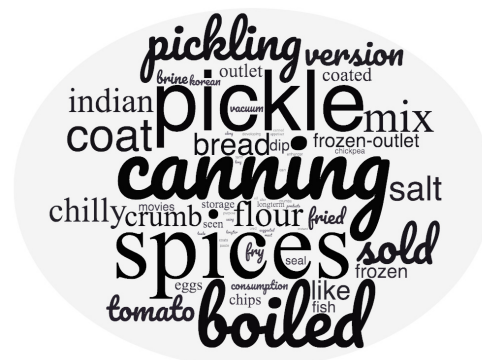


Fig. 5. Word cloud analysis of 1500 respondent's views on way to value add mollusc meat. The larger words indicate more frequent usage.

corded the data from the respondent staff which consist of female with 32.2% and 67.74% male staff. It was reported that the Department has the record that the edible freshwater mollusc which are generally consumed in Manipur consist of snail species such as *Filopaludina bengalensis*, *Brotia costula*, *Melanoides tuberculata/ Thiara tuberculata* and *Cipangopaludina dinalecythis* and mussel species such as *Lamellidens marginalis*. The Department do not have any records on the landing data of mollusc as the fisheries of mollusc is not currently occurring on record and it is considered under miscellaneous category. The departmental records of fish catch has a record that mollusc harvest occurs at a very negligible manner. Till date, no fishermen have shown any interest to farm mollusc and there were no training programmes on mollusc farming were organized.

Funding for research and development of freshwater mollusc aquaculture

Most of the respondents from Government Departments indicated there was limited scope for funding new species aquaculture development in Manipur and India at the larger picture. However, the government representative suggested a range of possible centrally sponsored scheme on development of inland fisheries and aquaculture by the Department of Animal Husbandry and Dairying, Govt. of India. These grant schemes are nation-wide and available both for specific industry setup and product development, as well as for more generic research and development. Overall, the opportunity to undertake research into the “*feasibility of aquaculture development of a new species in Manipur*” was expressed as ‘limited’ by all state Governments representative. Further, innovative research projects are frequently undertaken to assess new species and technology in Universities, supported by nationally competitive grant schemes. However, the Government agency respondents from all states were not aware of any previous enquiries specifically about freshwater snail or mussel aquaculture in Manipur.

Feedback from government officials identified some specific concerns that would have to be addressed prior to establishing mollusc aquaculture that includes:

- the species and its natural distribution
- detailed information on culture methods
- knowledge of disease status
- proposed farming structures

- stocking rates within the proposed area
- information on hatchery establishment that will be supplying the stock
- feeding requirements
- environmental impacts and whether they are ecologically sustainable species

Discussion

Given the growing world-wide demand for high quality food both from inland and marine resources (Tahergorabi *et al.*, 2011), it is time to explore the potential for diversification of the mollusc aquaculture industry in India. However, of the documented mollusc harvest for food consumption, bivalves constitute highest with 69.40 % (160,742,01 tonnes) whereas gastropods only contributed 2.20 % (516,618 tonnes) of the total (FAO, 2016). These values of global harvest were mainly from the marine sector. The freshwater harvest reports is not largely represented (FAO, 2016). This might be due to the fact that 97 percent of the earth’s water can be found in our ocean (NOAA, 2023) which means the freshwater bodies constitute only the remaining three percent. But for the hilly land lock region like the northeastern region of India where there is no marine water bodies, freshwater edible organisms are the only source of aquatic derived nutrition in the diet of the people. Freshwater snails and mussels are delicacy along the northeast region of India. This is well represented by the results of this study across various age group, income group and of all sections of educational qualifications. Consumers suggestions on value addition method such as picking and canning shows its potential for developing ready to eat food appetizer for income generation in this region and export within interstate or abroad.

Most of the respondents to our surveys did have some prior knowledge of freshwater molluscs as healthy food but only small proportions were aware of growing freshwater mollusc fisheries and aquaculture industry abroad. The techniques, which best suit the local conditions in Manipur of India need to be delivered to the local fishermen with the assistance from government to increase mollusc production through aquaculture development as conducted successfully for marine shellfish aquaculture training for the fisherman (Appukuttan, 1996). This will help to generate a reliable year round supply that will help to meet the increasing demand for meat and have less pressure in the natural stock.

The negligible data of mollusc harvest in the departmental record might be primarily because the collection occurs beyond the monitoring process. As per the information provide by the mollusc harvester, any mollusc harvester can collect any amount of freshwater mollusc such as bivalves or gastropods at any point of time from the public water bodies. The collection of snails and mussels at present are assuming to be at a huge quantity, as the snails and mussels are delicacy for Manipuri people. As such, only the collections of mollusc from wild are fulfilling the demands within the state. In the developed countries, adherence to the principles of the Environment Protection and Biodiversity Conservation Act 1999, if anything living organism has been collected from a wild or public water bodies, then, those collections have to be reported to the nearest Department or should be under proper licensing system. However, such regulations and monitoring process are not practise or might be due to the lack of awareness among the people of Manipur, till date there is no record in the government file. The lack of specific recreational fishing bag limits, or monitoring for the harvest mollusc species by Government regulatory bodies, provides further indication that these species are generally under-appreciated as a potential food source in India at large.

Fishermen along this region of northeast India do not have much awareness on the potential to culture and farming of mollusc. The government department has a very important role in increasing awareness on the nutritional value of freshwater snail and mussels to produce more shellfish through scientific aquaculture (Appukuttan, 1996). Funding for new species development is considered limited specifically in Manipur since current Indian Government prioritizes improving existing species aquaculture, or developing species with established markets for high value commercial export. The Fisheries Research Development Corporation has also trialed a subprogram for New and Emerging Aquaculture Species Development. A review of this program by Barneveld (2008) has recommended that rather than just focusing on emerging species as food, "new aquaculture initiatives" should encompass a range of aquaculture products including nutraceuticals, pigments, cancer prevention, pharmaceuticals, high value niche products for local and overseas fresh food markets and value-added food products, all of which are relevant to the development of a freshwa-

ter snail and mussel industry set up which are already been used in traditional medicine.

In countries like India, where freshwater snails and mussels are not widely consumed, strategic marketing is required to promote their nutritional and health values and support a domestic freshwater shellfish industry. Further research could focus on understanding how different people from other states of India perceive freshwater snails and mussels as food, which could then be used to target specific markets. Sensory evaluation of freshwater snails and mussels meat with different preparations such as boiled, fried and steamed could be undertaken with attributes such as taste, flavor, smell and texture (Joram and Kapute, 2016). Descriptive tests have been undertaken on canned marine snails using attributes such as sweet, salt, sour, bitter, metallic, hardness and chewiness (Sanchez-Brambila *et al.*, 2002). Preference tests can be used to compare between two samples by keeping the first sample as reference control (e.g squid tissue), whereas second freshwater snails and mussels sample could be adopted to understand taste preference of the consumer (Sanchez-Brambila *et al.*, 2002). The basic understanding of how people perceive the meat of freshwater snails and mussels will help provide the direction for future promotion and market development.

Conclusion

Overall this study investigated the potential for value-adding the freshwater molluscan resources of Manipur, India. This study further established the scientific fact that, freshwater snails and mussels are a delicacy for this region of northeast India. However, continuous harvest from the wild could be a question to the sustainability in the long-term fisheries. This study also emphasized the need to undertake strategic monitoring program by the Government regulatory bodies for the shellfish harvest from the wild. Consumer perceptions and suggestions also deliver the potential to promote and conduct more research on the nutritional and health benefits of snails and mussels meat and value-add the freshwater molluscan industry. Secondary resources such as shells and viscera could also increase its utilisation instead of wasting in household levels, but it is imperative that a sustainable supply is first established.

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Conflict of interest

The authors declare that there is no conflict of interest.

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